Kankichi SOHMA*: Pollen morphology of the Japanese species of *Utricularia* L. and *Pinguicula* L. with notes on fossil pollen of *Utricularia* from Japan (1)**

相馬寛吉*: 日本産タヌキモ属およびムシトリスミレ属の花粉形態とタヌキモ属の化石花粉について (1)**

Introduction

The genus *Utricularia* is distributed widely through the tropics and has a few species in the temperate regions. It has been considered to consist of as many as 120 or more species. Only about 10 to 12 of them are currently recognized as free-floating or anchored aquatics, epiphytes in wet mosses, or terrestrial plants of wet to moist soils in Japan.

As might be expected of carnivorous plants, many comparative works regarding the characteristics of the bladders on the leaves and other morphological observations have been published by Goebel (1889, 1891), Arber (1920), Lloyd (1942) and others. Taxonomic treatments of the genus include the works of De Candolle (1844), Benjamin (1847), Kamienski (1895), Barnhart (1916) and Komiya (1973). The descriptions of the species given by the various floras are also concerned sometimes with taxonomic and nomenclatorial works, e. g. Bentham (1869), Barnhart (1933), Taylor (1963, 1964) and Ceska and Bell (1973). A biosystematic study of the North American species has been carried out by Kondo (1972). The Japanese species of *Utricularia*, however, are poorly characterized in most standard references, especially with respect to the pollen morphology.

In the present investigation the pollen grains of the ten species of *Utricularia* represented in Japan, including some infraspecific categories, are described in relation to the finding of fossil grains comparable with those of this genus. In order to have a basis for evaluation of the rather heteromorphic pollen types of *Utricularia*, the author has paid a special

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attention to the recognition of the specific differences in the pollen characters between both modern and fossil grains. In addition, another member of the family, *Pinguicula*, which is represented in Japan by only two species, was also studied palynologically.

Previous works on pollen morphology

Among earlier works describing the pollen of the Lentibulariaceae, De Candolle (1844) may be mentioned. In the familial diagnosis he stated that "pollen (aquâ non immersum) late ellipsoideum". He noted further that the pollen grains of *Pinguicula* are "ovoideo-globosum". The morphological study on the pollen grains of the genus *Utricularia* was made in part by Fischer (1890). Later this genus was investigated palynologically from time to time, e.g. Faegri and Iversen (1950) in their "Textbook of Modern Pollen Analysis" and again their second revised edition (1964) include *Utricularia* in the key to Northwest European pollen types. Erdtman (1952) gave a brief pollen morphological description of three species of *Utricularia*, and subsequently he (1954) treated two species of it.

Five Japanese species, i.e. *U. exoleta*, *U. tenuicaulis*, *U. bifida*, *U. yakushimensis* and *U. racemosa*, have been described and illustrated by Ikuse (1956).

The Scandinavian species, *U. neglecta*, is described in "An Introduction to a Scandinavian Pollen Flora" by Erdtman, Berglund and Praglowski (1961), and in addition to it, *U. minor* and *U. vulgaris*, are included in the "Pollen and Spore Key" by Nilsson and Praglowski (1963). Two species, *U. flexuosa* and *U. minor*, native to the Western Himalayan region have been observed palynologically by Nair (1965). Thanikaimoni (1966) distinguished three groups within the Indian species of the genus based on pollen characteristics. He noted further that the species belonging to these three groups are well characterized by three distinct habits (aquatic, terrestrial and epiphytic) and three distinct types of seed (winged, scrobiculate or reticulate or striatoreticulate, and glochidiate or cosmose). A comprehensive pollen morphological study has been undertaken on about 143 species of *Utricularia* by Huynh (1968). He distinguished five groups based on the general characters of pollen, and presented discussions from both palynotaxonomical and palynogeographical points of view.

Utricularia tenuis, a Chilean species, is included in "Pollen and Spores of Chile" by Heusser (1971). Huang (1972) included descriptions of eight species of Formosan *Utricularia*, and three-fourths of them are thought to be represented in Japan. In his biosystematic study, Kondo (1972) reported on the quantitative characters of the pollen grain diameter of *U. cornuta* and *U. juncea* found in the Southeastern United States. Shimakura (1973) has given a few words on the pollen morphology of *U. vulgaris*.

Materials and methods

The materials for this study were collected from the herbarium specimens available in the following herbaria: Biological Institute, Tohoku University (TUS); Department of Botany, Tokyo University (TI); National Science Museum, Tokyo (TNS); Makino Herbarium, Tokyo Metropolitan University, Tokyo (MAK); and Department of Biology, Nippon Dental College, Tokyo (NDC). I am grateful to the directors and to the curators of these herbaria for their generosity in sharing the materials.

Since some observed morphological variations in the vegetative structures of the species of *Utricularia* may be correlated with the differences in habitats, the individual plants are often difficult to identify from published literatures. Therefore, the materials studied were taken from the specimens which have been identified critically by Dr. S. Komiya, Department of Biology, Nippon Dental College, and the author.

Several collections of a species have been studied, when possible, to see if the geographical variations or morphological differences are reflected in the pollen grains. In some cases, however, the number of specimens were insufficient to permit studies of more than one sheet.

The pollen grains used were acetolyzed in the same way as described by Erdtman (1969) and mounted in silicone oil with a refractive index of 1.40. The slides were sealed with paraffin or nail polish. The figures as a rule, are based on at least 20 measurements.

A JEOL-SEM-3B scanning electron microscope was used to obtain the scanning electron micrographs. The pollen samples examined by the scanning electron microscope were subjected to the same acetolysis treatment used for light microscopic study, then transferred from water to adhesive tape and allowed to dry. The samples were coated with gold

before placement within the microscope.

The species described here are arranged principally according to the De Candolle's system of 1844.

Description of the pollen grains of *Utricularia* and *Pinguicula*

General account

Pollen grains principally tricolporate or stephanocolporate; usually isopolar; shape varies from rounded-triangular or circular to polygonal in polar view; oblate to prolate in equatorial view; size varies greatly, abnormally minute grains with the diameter of 3 μ in *Utricularia intermedia* f. *ochroleuca* to exceptionally giant grains in the same specimen with more than 100 μ in diameter, but generally P: 15–30 μ × E: 18–35 μ in diameter; furrows meridional, medium to long in length, more or less open at equator, 3–24 in number, slightly to strongly intruded, frequently confluent at their apices in certain species, membrane obscure; pores ellipsoidal in shape, arranged zonally or connected on equatorial girdle—connected pores in this condition are described as a transverse furrow in the following chapter; exine tectate, ca. 2 μ in thickness, maximum thickness near the pores, ektexine thicker than endexine, columellae simple, minute and distinct.

Detailed account

Utricularia vulgaris L., Sp. Pl. 18, 1753. (Fig. 1).

Syn.: *U. japonica* Makino in Bot. Mag. Tokyo, **28**: 28, f. 3, 1914.–Miki in Bot. Mag. Tokyo, **49**: 852, f. 13, 1935.–Hara in Bot. Mag. Tokyo, **51**: 639, 1937.–Hara in Enum. Sperm. Jap. **1**: 292, 1949.–Ohwi in Fl. Jap. 815, 1965.

U. siakujiiensis Nakajima in Tokyo-Ryokuchi-Keikaku-Chôsa Ihô **9**: 90, t. 2, 1937.–Hara in Enum. Sperm. Jap. **1**: 293, 1949.–Ohwi in Fl. Jap. 815, 1965.

Voucher Specimens: Natsudomari, Mutsu; Y. Takeuchi, July 24, 1960, *U. japonica* in TUS 15246; Slide No. 1936. Hacchô-ike-shita, Tanabu, Mutsu; M. Mizushima, Aug. 8, 1955, TI; Slide No. 2038.

Compare: *U. vulgaris*, Fischer, 1890, p. 54. *U. vulgaris*, Erdtman, 1952, p. 233. *U. vulgaris*, Jonas, 1952, p. 42, pl. 32, figs. 1a, 1b. *U. vulgaris*, Erdtman, 1954, p. 105, pl. 14, fig. 242. *U. vulgaris*, Nilsson & Praglowski, 1963, p. 60. *U. vulgaris*, Huynh, 1968, p. 21, 28, figs. 23–24. *U. japonica*, Huynh, 1968, p. 38. *U. vulgaris*, Huang, 1972, p. 157, pl. 98, figs. 24–26. *U.*

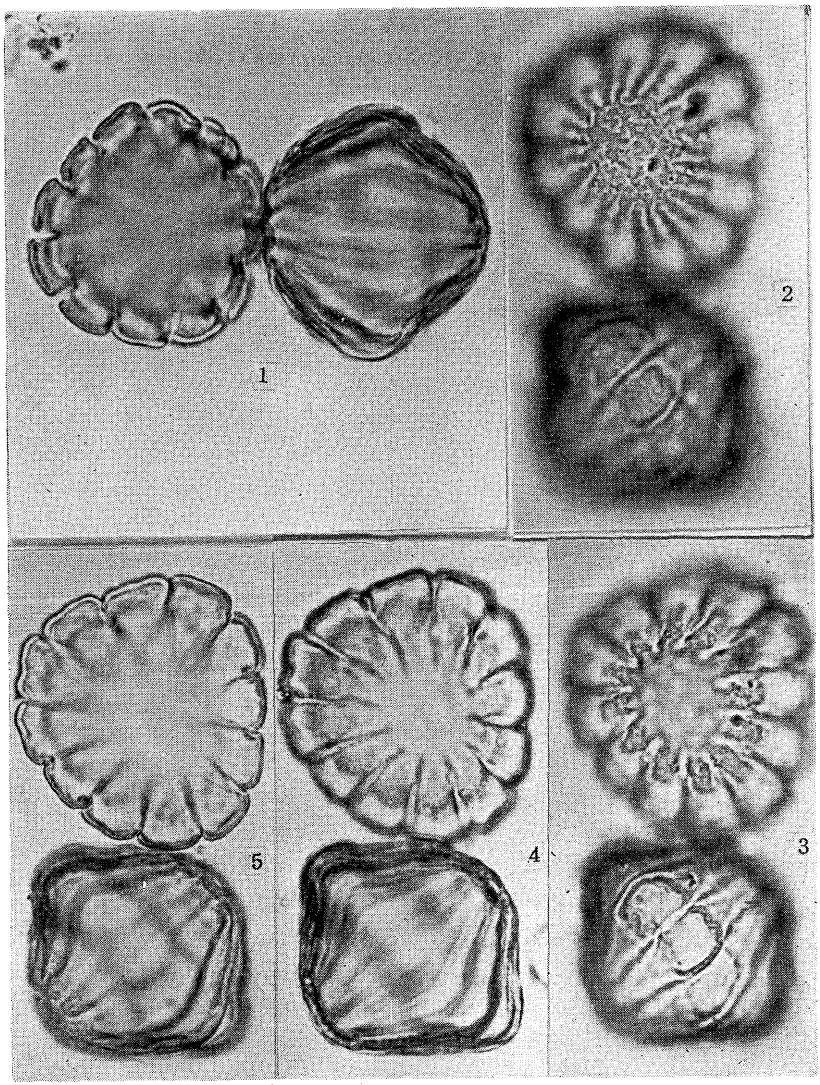


Fig. 1. *Utricularia vulgaris* L. Slide no. 1936. ×1000. Figs. 2-5. *Utricularia vulgaris* L. f. *tenuicaulis* (Miki) Komiya. Slide no. 1933. ×1000.

vulgaris, Shimakura, 1973, p. 46, pl. 91, figs. 1043–1046.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; mostly oblate or suboblate to oblate spheroidal or prolate spheroidal, rarely subprolate in equatorial view; size P: 20.8–32.2×E: 26.5–36.4 μ or P: 27.6–33.8×E: 27.0–31.2 μ, average P: 28.3×E: 32.6 μ or P: 30.1×E: 28.7 μ in diameter; circular to rounded-tetragonal or polygonal in polar view; furrows meridional, medium to long in length, narrowly open, 11–15 in number, without marginal thickening, intruding strongly, apex acute, confluent sometimes at apices, membrane obscure; a transverse furrow on equatorial girdle running mostly zonal with psilate to scabrate ektexine loosened from endexine, often referred to as "cavate", 3.1–8.8 μ high; exine tectate, about 1.5 μ thick, thickened more or less at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas where about 1 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation psilate to scabrate.

Remarks: The specimen collected from Natsudomari, Mutsu, differs from that of Hacchô-ike-shita, Mutsu, by having dominant pollen grains that are prolate spheroidal to subprolate in equatorial view.

Utricularia vulgaris L. f. **tenuicaulis** (Miki) Komiya, Sys. Stud. Lentibulariaceae 89, 1972. (Figs. 2–5).

Syn.: *U. tenuicaulis* Miki in Bot. Mag. Tokyo, **49**: 847, f. 12, 1935, pro sp.–Miki in Water Phaner. Jap. f. 66, 1937.–Hara in Enum. Sperm. Jap. 1: 293, 1949.–Ohwi in Fl. Jap. 815, 1965.

Voucher Specimen: Funaoka-Tsukinoki, Rikuzen; S. Sugaya, H. Ogura & C. Kimura, Aug. 12, 1954, TUS 5890; Slide No. 1933.

Compare: *U. tenuicaulis*, Ikuse, 1956, p. 136, pl. 36, fig. 13.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; mostly suboblate to oblate, rarely oblate spheroidal in equatorial view; size P: 22.4–29.1×E: 31.2–41.6 μ, average P: 27.0×E: 34.0 μ in diameter; rounded-triangular to circular in polar view; furrows meridional, medium to long in length, narrowly open, 10–14 in number, without marginal thickening, intruding strongly, apex acute, confluent rarely at apices, membrane obscure; a transverse furrow on equatorial girdle running mostly

zonal with scabrate ektexine loosened from endexine, often referred to as "cavate", 4.2–7.8 μ high; exine tectate, about 1.5 μ thick uniformly, decreasing in thickness towards furrow margins, less thick at polar areas where about 1 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation psilate to scabrate.

Remarks: The grains mentioned here much resemble those of *U. vulgaris* from Hacchô-ike-shita, Tanabu, Mutsu, Slide No. 2038.

Utricularia dimorphantha Makino, Bot. Mag. Tokyo, **20**: 96, 1906. (Figs. 6–9).

Voucher Specimen: Honda-ike, Zeze, Omi; I. Sono, July, 1904, TNS 15778; Slide No. 2163.

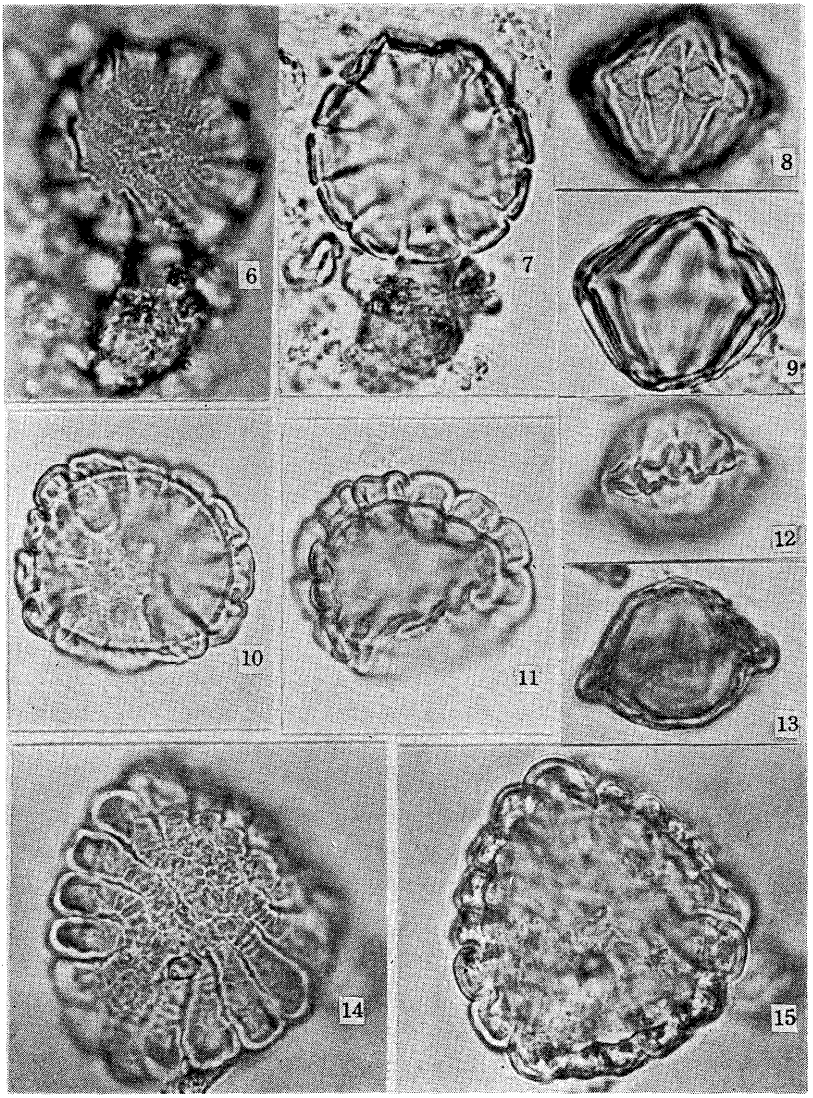
Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; mostly suboblate, rarely oblate or oblate spheroidal to prolate spheroidal in equatorial view; size P: 19.5–26.5×E: 25.0–31.5 μ, average P: 23.0×E: 28.3 μ in diameter; circular to polygonal in polar view; furrows meridional, medium in length, narrowly open, 12–16 in number, without marginal thickening, intruding strongly, apex acute, confluent sometimes at apices, membrane obscure; a transverse furrow on equatorial girdle running zonally with psilate to scabrate ektexine loosened from endexine, often referred to as "cavate", 2.5–3.7 μ high; exine tectate, about 2 μ thick, thickened markedly at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas where about 1 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation psilate to more or less scabrate, scabrae on polar areas not closely spaced.

Remarks: The area of geographical distribution is confined to Japan.

Utricularia intermedia Hayne in Dreves et Hayne, Bot. Bilderbuch III, t. 17, 1798. (Figs. 10–15).

Voucher Specimens: Shiriya-zaki, Mutsu; H. Ohashi 4360, July 30, 1964, TUS 5940; Slide No. 1982. Toikanbetsu, Teshio, Hokkaido; H. Hara, July 20, 1956, *U. multispinosa* in TI; Slide No. 2036. Ylikiiminki, Ostrobotnia, Finland; P.S. Jokela, July 10, 1965, MAK 56386; Slide No. 2161.

Compare: *U. intermedia*, Fischer, 1890, p. 54. *U. intermedia*, Erdtman, 1952, p. 233. *U. intermedia*, Huynh, 1968, p. 23, 38, fig. 31.



Figs. 6-9. *Utricularia dimorphantha* Makino. Slide no. 2163. ×1000. Figs. 10-15. *Utricularia intermedia* Hayne. Figs. 10-13, no. 2036. ×1000, Figs. 14-15, Slide no. 1980. ×1000.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; mostly oblate to suboblate, rarely oblate spheroidal to prolate spheroidal in equatorial view; size variable, generally P: 16.6–33.8×E: 26.5–38.5 μ, average P: 25.7×E: 32.5 μ in diameter; rounded-triangular to circular in polar view; furrows meridional, medium to long in length, narrowly open, 11–18 in number, without marginal thickening, intruding strongly, apex acute, confluent frequently at apices, membrane obscure; a transverse furrow in equatorial girdle running mostly oblique to rarely zonal, sometimes interrupted halfway, with psilate to scabrate ektexine loosened from endexine, often referred to as "cavate", 3.6–7.5 μ high; exine tectate, about 2 μ thick, thickened markedly at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas where about 1.5 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation scabrate to verrucate or rugulate, often with irregular sculpture resembling wrinkles, nearly parallel to transverse lines on intercolpia and on polar areas remarkable.

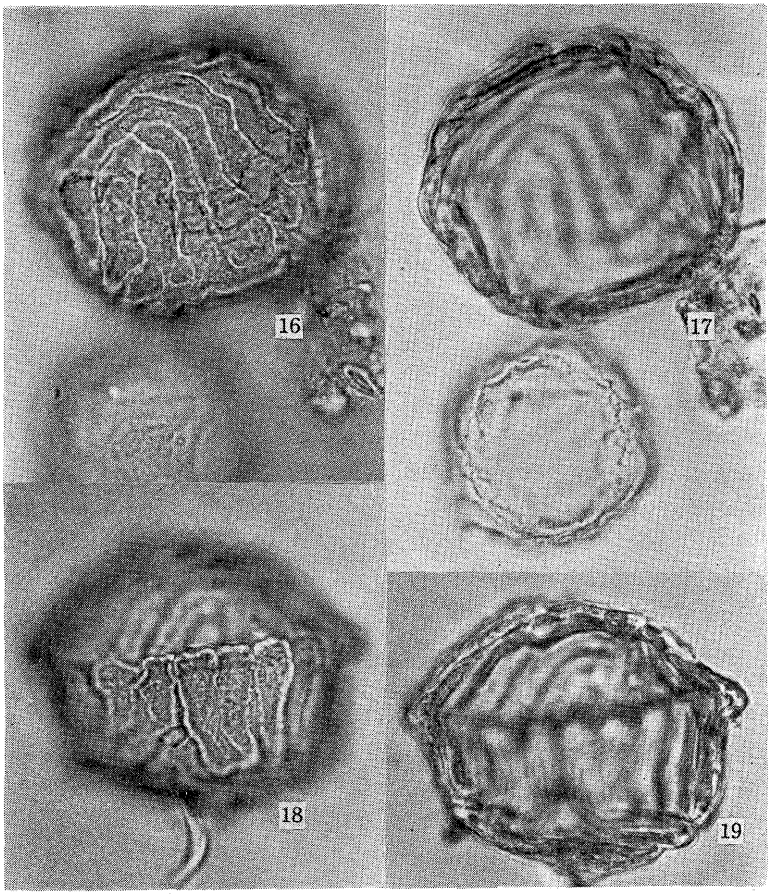
Remarks: The grains of the specimen collected from Toikanbetsu, Hokkaido, deviate from those from Shiriya-zaki, Mutsu, on the one hand and from Finland on the other. The first specimen mentioned differs from the other two specimens by having dominant pollen grains that are oblate in equatorial view. The remarkable exine ornamentation with parallel wrinkles on the intercolpia is also much reduced in this specimen. In the collection from Shiriya-zaki, Mutsu, aberrant grains without apertures are often encountered. In the Finnish collection prolate spheroidal grains with larger size both for the polar length and the equatorial diameter are sometimes met with.

Utricularia intermedia Hayne f. **ochroleuca** (R. Hartm.) Komiya, Sys. Stud. Lentibuariaceae 76, 1972. (Figs 16–19).

Syn: *U. ochroleuca* R. Hartman in Bot. Notiser 30, 1857.–Miki in Water Phaner. Jap. 113 & 115, f. 61, 1937.–Hara in Enum. Sperm. Jap. 1: 292, 1949.

Voucher Specimens: Yachi, Mt. Hakkoda, Mutsu; S. Sugaya & K. Omiya, July 2, 1960, TUS 5915; Slide No. 1935. Yama-no-hana, Oze, Kôzuke, H. Okuyama, July 22, 1934, TNS 44877; Slide No. 2168.

Compare: *U. ochroleuca*, Huynh, 1968, p. 36.



Figs. 16-19. *Utricularia intermedia* Hayne f. *ochroleuca* (R. Hartm.) Komiya. Slide no. 1935. ×1000.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; mostly suboblate to oblate, rarely oblate spheroidal to prolate spheroidal in equatorial view; size variable, generally P: 20.0–35.0× E: 27.0–43.0 μ, average P: 27.5×E: 35.1μ in diameter; circular to polygonal in polar view; furrows principally meridional, long narrow, 13–24 in number, without marginal thickening, intruding strongly, apex acute, confluent

mostly at apices, membrane obscure; a transverse furrow on equatorial girdle running mostly oblique, frequently interrupted halfway, with granulate to verrucate ektexine loosened from endexine, often referred to as "cavate", 2.5–5.0 μ high; exine tectate, about 2.0–2.5 μ thick, thickened markedly at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas where about 1.5 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation scabrate to verrucate or rugulate, often with irregular sculpture resembling wrinkles nearly parallel to transverse lines on intercolpia and on polar areas remarkable.

Remarks: The grains of the specimen from Mt. Hakkoda exhibit extensive size variations as well as exine ornamentation. These deviate much from the general size range by having grains with only several micra to more than 100 μ in diameter. Besides having remarkably thickened exine some of these grains are spiraperturate with conspicuous ornamentation stated by Huynh (1968) as "c'est le tectum des mésocolpiums qui forme des mamelons, orientés parallèlement à l'équateur détachant ainsi les bacules infratectaux de leur socle".

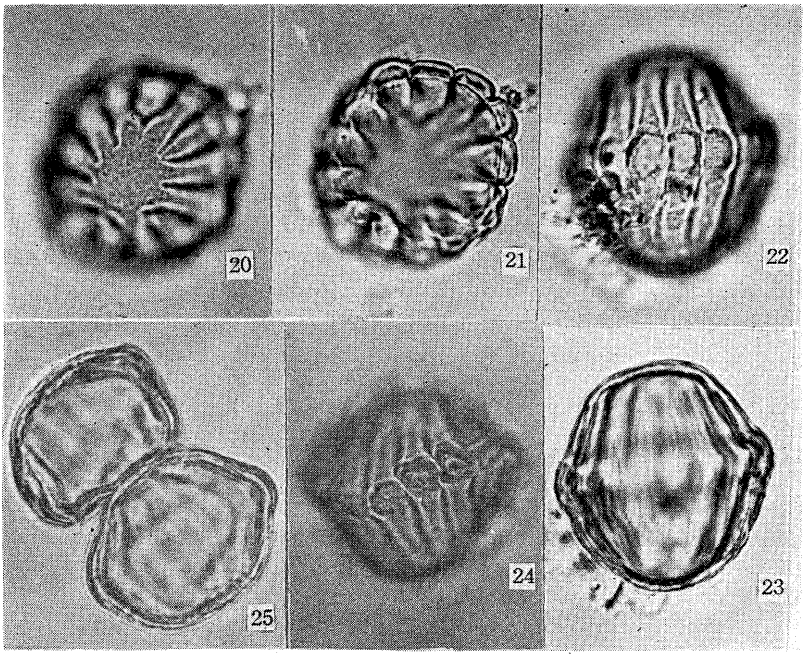
Utricularia minor L., Sp. Pl. 18, 1753. (Figs. 20–25).

Syn: *U. multispinosa* Miki in Water Phaner. Jap. 115, f. 63, 1937.–Hara in Enum. Sperm. Jap. 1: 292, 1949.–Ohwi in Fl. Jap. 815, 1965.

Voucher Specimens: Alingsås, Västergötland, Sweden; M. Griksson, July 1892, TNS 200936; Slide No. 2162. Thielens-Devos, Belgium; Verheggen; Apr. 1829, MAK 96176; Slide No. 2166. Ooupehau, Belgium; Coll. unknown May 9, 1867, MAK 53833; Slide No. 2169.

Compare: *U. minor*, Fischer, 1890, p. 54. *U. minor*, Jonas, 1952, p. 42, pl. 32, fig. 3. *U. minor*, Erdtman, 1952, p. 233. *U. minor*, Erdtman, 1954, p. 107. *U. minor*, Nilsson & Praglowski, 1963, p. 60. *U. minor*, Nair, 1965, p. 34. *U. minor*, Thanikaimoni, 1966, p. 269–270, pl. 1, figs. 3, 4. *U. minor*, Huynh, 1968, p. 38.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometime to as "zonorate" or "synorate"; mostly suboblate, occasionally oblate spheroidal, rarely oblate and even prolate spheroidal in equatorial view; size variable, generally P: 17.0–28.0×E: 21.0–31.0 μ, average P: 23.6×E: 25.6 μ in diameter; circular to



Figs. 20-25. *Utricularia minor* L. Figs. 20-23, Slide no. 2169. ×1000.
Figs. 24-25, Slide no. 2162. ×1000.

rounded-tetragonal or -pentagonal in polar view; furrows meridional, medium to long in length, narrow, 11–18 in number, without marginal thickening, intruding strongly, apex acute, confluent sometimes at apices, membrane obscure; a transverse furrow on equatorial girdle running zonally to often obliquely, or sometimes interrupted halfway with scabrate ektexine loosened from endexine, often referred to as "cavate", 3.0–5.5 μ high; exine tectate, about 2 μ thick, thickened markedly at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas where about 1–1.5 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation psilate, scabrate to finely reticulate.

Remarks: The description is based on European specimens, thus the grains of the Japanese specimen remain untouched. The grains from two Belgian specimens differ from those of Sweden by having aberrant pollen grain that are reduced minutely in size.

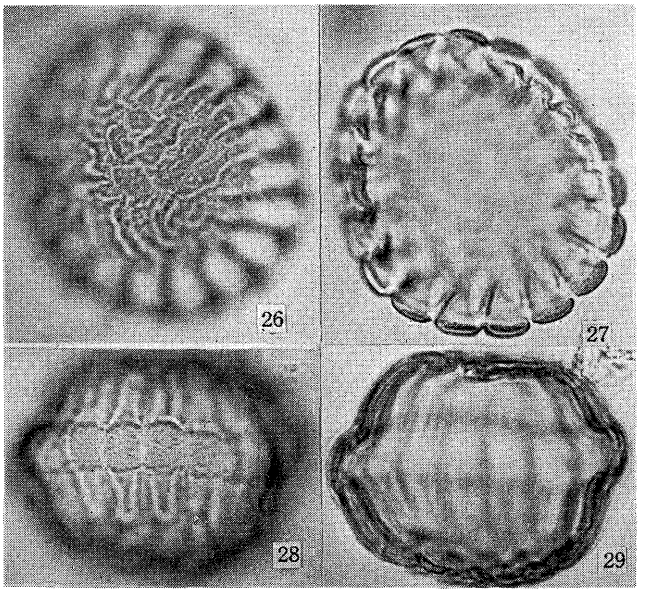
Utricularia aurea Loureiro, Fl. Cochinch. 1 : 26, 1790. (Figs. 26-29).

Syn : *U. pilosa* Makino in Bot. Mag. Tokyo 11 : 70, 1897. in text ; 16 : 135, 1900. nom. nud. ; 20 : 97, 1906.-Matsum. in Ind. II-2 : 579, 1912.-Miki in Water Phaner. Jap. f. 64, 1937.-Hara in Enum. Sperm. Jap. 1 : 292, 1949.-Ohwi in Fl. Jap. 815, 1965.

Voucher Specimens : Mitagaya, Musashi ; N. Murayama, Sept. 1950, TUS 5914 ; Slide No. 1934. Shinobu-yama, Izumi ; Yoshino, Sept. 29, 1940, TI ; Slide No. 2035. Teganuma, Shimôsa ; I. Furusawa, Aug. 1951, MAK 4728 ; Slide No. 2164.

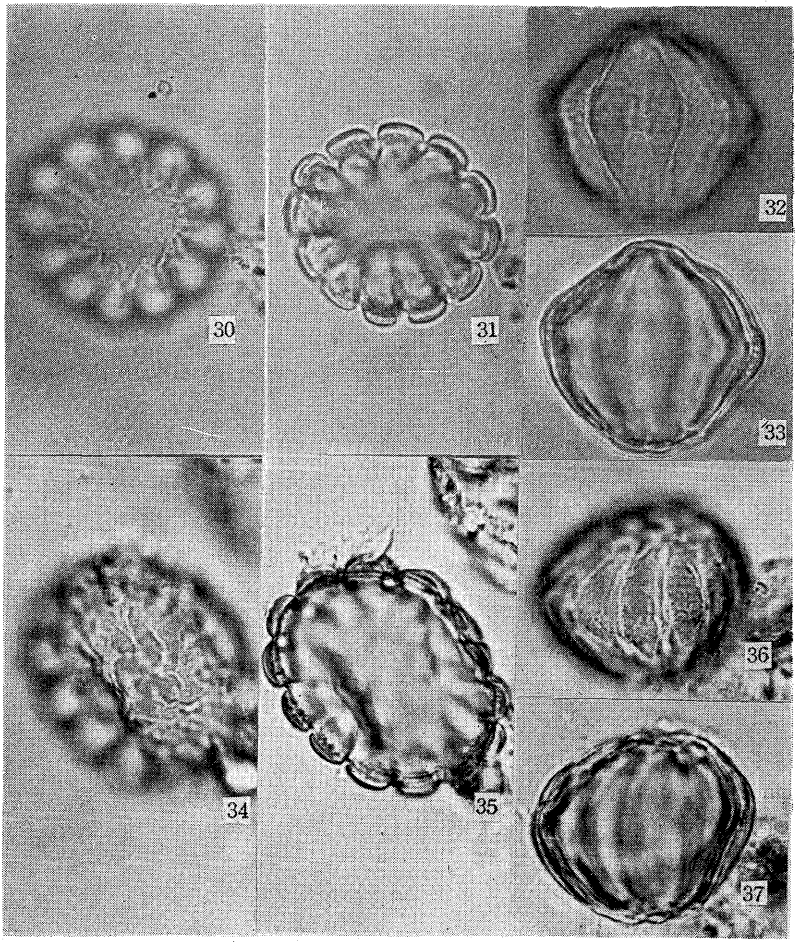
Compare : *U. aurea*, Thanikaimoni, 1966, p. 266-268, pl. 2, figs. 1, 2. *U. aurea* Huynh, 1968, p. 36. *U. pilosa*, Huynh, 1968, p. 38. *U. aurea*, Huang, 1972, p. 156, pl. 98, figs. 5-10.

Description : Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as " zonorate " or " synorate " ; mostly oblate to suboblate, rarely oblate spheroidal to prolate spheroidal in equatorial view ; size P : 23.4-35.9×E : 30.0-46.3 μ, average P :



Figs. 26-29. *Utricularia aurea* Loureiro. Slide no. 1934. ×1000.

29.2×E: 38.2 μ in diameter; circular to rounded-tetragonal or -pentagonal in polar view; furrows meridional, medium to long in length, narrowly open, 15–23 in number, without marginal thickening intruding strongly, apex acute, confluent mostly at apices, membrane obscure; a transverse furrow on equatorial girdle running slightly oblique with minute granulated ektexine loosened from endexine, often referred to as "cavate", 3.1–7.5 μ



Figs. 30-33. *Utricularia gibba* L. subsp. *gibba* (L.) P. Taylor. Slide no. 2034. ×1000. Figs. 34-37. *Utricularia gibba* L. subsp. *exoleta* (R. Br.) P. Taylor. Slide no. 2165. ×1000.

high; exine tectate, about 2.0–2.5 μ thick, thickened markedly at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas where about 1.5 μ thick, ektexine thicker than endexine, columellae simple, about 0.5 μ high and distinct; exine ornamentation psilate to often scabrate or verrucate, on polar areas verrucae distinct.

Remarks: The specimen collected from Shinobu-yama, Izumi, has much thicker exine, but is otherwise quite similar to the other two collections.

Utricularia gibba L. subsp. **gibba** (Figs. 30–33).

Voucher Specimen: Cult. in Bot. Dept., Tokyo Univ.; H. Hara, Sept. 5, 1951, TI; Slide No. 2034.

Compare: *U. gibba*, Huynh, 1968, p. 37–38.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; mostly oblate spheroidal, rarely suboblate and even prolate spheroidal to subprolate in equatorial view; size P: 25.5–29.1×E: 27.6–33.3 μ or P: 29.1–30.5×E: 25.0–27.9 μ, average P: 27.6×E: 30.9 μ or P: 29.7×E: 26.8 μ in diameter; circular in polar view; furrows meridional, medium in length, narrowly open, 10–13 in number, without marginal thickening, intruding strongly, apex acute to blunt, rarely confluent at apices, membrane smooth; a transverse furrow on equatorial girdle running zonally with psilate to scabrate ektexine loosened from endexine, often referred to as "cavate", without prominent margins, less thick at polar areas, about 1 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation psilate to scabrate, sculpturing elements at zonal portion of intercolpia more or less loosened.

Remarks: The grains of subsp. *gibba* differ from those of subsp. *exoleta* by having larger grain without warty exine ornamentation at polar areas. This is one of the exotic taxa introduced recently to Japan from the United States and is thought to have been naturalized often as a member of aquatic flora near Nogoya (Komiya, 1972).

Utricularia gibba L. subsp. **exoleta** (R. Br.) P. Taylor in Mitt. Bot. Staat. Münch. **4**: 101, 1961. (Figs. 34–37).

Syn.: *U. exoleta* R. Brown in Prod. Fl. Nov. Holl. 1: 430, 1810.–Matsum. in Ind. II-2: 579, 1912.–Miki in Bot. Mag. Tokyo **49**: 847, f. 11, 1935.–Masamune in Trans. Nat. Hist. Formos. **30**: 413, 1940.–Hara in Enum.

Sperm. Jap. 1 : 291, 1949.-Ohwi in Fl. Jap. 815, 1965.

Voucher Specimens: Hômei, Owari; K. Inami, Aug. 15, 1948, TNS 79827; Slide No. 2165. Iriomote, Ryukyu; T. Amano, June 27, 1953, TNS 109090; Slide No. 2167.

Compare: *U. exoleta*, Ikuse, 1956, p. 136. *U. gibba* subsp. *exoleta*, Thanikaimoni, 1966, p. 268, pl. 1, figs. 1-2. *U. exoleta*, Huynh, 1968, p. 37. *U. exoleta*, Huang, 1972, p. 156.

Description: Pollen grains stephanocolporate with a fused transversal furrow at equatorial girdle, simply referred sometimes to as "zonorate" or "synorate"; about half of them oblate spheroidal, the rest suboblate, oblate and even rarely prolate spheroidal in equatorial view; size variable, P : 16.0-28.5×E : 24.0-32.0 μ, average P : 20.8×E : 27.4 μ in diameter; circular to rounded-tetragonal in polar view; furrows meridional, medium in length, narrowly open, 13-16 in number, without marginal thickening, intruding strongly, apex acute, confluent sometimes at apices, membrane obscure; a transverse furrow on equatorial girdle running zonally with scabrate ektexine loosened from endexine, often referred to as "cavate", 2.0-3.0 μ high, without prominent margin; exine tectate, about 2 μ thick, thickened markedly at centre of intercolpia, decreasing in thickness towards furrow margins, less thick at polar areas, about 1 μ thick, ektexine thicker than endexine, columellae simple, minute and distinct; exine ornamentation psilate except at zonal portion of intercolpia and polar areas, the former scabrate, the latter irregularly warty.

Remarks: The specimen collected from Iriomote, Ryukyu, differs greatly by having no stephanocolporate grains. They are all of the inaperturate type of grains with conspicuous warty exine ornamentation. Therefore, the grains from Ryukyu are likewise aberrant and differ from the general type of this taxon.

(To be continued)